

Tailored Magnetic Heterostructures

More linear and more sensitive sensors with new magnetic multilayer technology

Recent discovery of the giant magnetoresistance (GMR) effect will make possible marked improvements in the performance of magnetoresistive sensors. Discovered in 1988, the GMR effect is the very large change in electrical resistance that is observed in ferromagnetic-paramagnetic multilayer structures when the relative orientations of the magnetic moments in alternate ferromagnetic layers change as a function of applied field.

Magnetic multilayer technology is coming to the marketplace

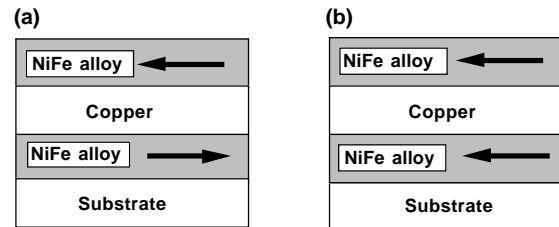
GMR sensors potentially can be designed to be more sensitive and more linear at low applied fields than traditional magnetoresistive sensors. This increased sensitivity and linearity will significantly reduce the micromagnetic problems that plague many single-film designs. The magnetically closed multilayer structure of GMR devices may also inhibit domain formation and help prevent problems with Barkhausen noise.

Many research groups have recently demonstrated the GMR effect in multilayers based on magnetically soft nonmagnetoresistive materials like the industry standard, permalloy ($\text{Ni}_{81}\text{Fe}_{19}$ alloy). One group has demonstrated a normalized change in resistance of 6.5% at a saturation field of only 8 Oe in a permalloy-copper multilayer. The GMR

effect should offer improvements in sensitivity for applications as varied as magnetic recording systems, electronic ignition systems, tachometers, and robotics.

APPLICATIONS

- Magnetoresistive read heads for magnetic recording
- Ac and dc magnetometers
- Linear and rotary position sensors
- Tactile sensors for robotics
- Scanners for nondestructive evaluation
- Nonvolatile, thin-film, magnetic memory devices



When an external field is applied to a magnetic multilayer, the magnetic moments reorient, causing a large change in electrical resistance. (a) Zero-field, high-resistance state; (b) high-field, low-resistance state.

Flexible, versatile manufacture of magnetic heterostructures

At LLNL, we use ion-beam sputtering to fabricate magnetic heterostructures. Ion-beam sputtering uses a single, fixed ion source to deposit alternate layers from multiple targets on a rotating carousel. Both conducting and insulating materials can be deposited with the same equipment. We then use LLNL's state-of-the-art analytical capabilities as well as vibrating-sample magnetometry and SQUID magnetometry to characterize the samples.

Availability: Magnetic heterostructures are available now. We invite collaboration with industrial partners to develop these heterostructures into testable, prototype sensors.

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